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ABSTRACT

Three studies investigated the effects of concrete versus abstract wording and negative versus positive premises on the difficulty subjects had in solving several kinds of reasoning tasks. Subjects for all three studies were college undergraduates who received booklets containing either hypothetical, disjunctive, or linear syllogisms. Each booklet explained the difference between "valid" and "true" and gave an example of a valid untrue categorical syllogism. For each problem in the booklets, subjects were given two premises and instructed to write out a valid conclusion. Half the problems were constructed with positive premise components, and half included negatives; half used concrete nouns, and half used abstract words. After finishing the problems, subjects were asked to write whether they had used a special method for solving the problems and whether they had formed mental images. Subjects were also asked to specify their sex, year in school, and whether they had ever studied logic. Results showed that valid problems were easier to solve and that negation made the syllogisms harder, except for invalid hypothetical problems. The effect of concreteness depended on problem type: it facilitated hypothetical, hindered disjunctive, and had no impact on linear reasoning. (FL)

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# THE EFFECTS OF CONCRETENESS AND NEGATION ON THE DIFFICULTY OF HYPOTHETICAL, DISJUNCTIVE AND LINEAR SYLLOGISMS

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By

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## Abstract

The effects of concrete v. abstract wording and negative v. positive premises were investigated, using hypothetical, inclusive disjunctive and three-term linear syllogisms. Valid problems are easier to solve. Negation makes syllogisms harder, except for invalid hypothetical problems. In those instances, use of a negative actually makes the syllogism easier. The effect of concreteness depends on problem type: it facilitates hypothetical, hinders disjunctive and has no impact on linear reasoning.

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THE EFFECTS OF CONCRETENESS AND NEGATION ON THE DIFFICULTY OF HYPOTHETICAL, DISJUNCTIVE AND LINEAR SYLLOGISMS

Reasoning is a foundational activity in human communication. People make inferences about what they perceive, what they remember, what they ought to say, and what is being said to them. The intrapersonal level of communication is mental action taken in regard to the external world. Some of this action is obviously inferential, and much of the rest has its roots in reasoning. This much is uncontroversial.

How to model human inference is not so clear. There is a widespread opinion in both psychology (e.g., Nisbett & Ross, 1980; Evans, 1982) and communication (e.g., Delia, 1970; Willard, 1980) that human reasoning is not logical. Yet at virtually every turn we find theoretic units which greatly resemble syllogisms. The practical syllogism has been harnessed for use by several varieties of rules theorists (Cronen, Pearce & Harris, 1979; Shimanoff, 1980; Smith, 1982, ch. 3). A more or less syllogistic application of an observation to a general principle in order to generate conclusions about other people seems to be assumed in theories of person perception (e.g., Cook, 1971; Delia, O'Keefe & O'Keefe, 1982). System theorists claim that an organism steers itself by comparing its current state to a goal state, and choosing behaviors which will more closely approach the goal (Miller, Galanter & Pribaum, 1960; Fisher, 1978, ch. 7; Littlejohn, 1978, ch. 2); such self-regulation can easily be expressed in logical form. Exchange theory, too, regards people as rational, logical evaluators of relationships (Kelley & Thibaut, 1978; Roloff, 1981). Even argumentation, which has resisted the syllogism's yoke with more energy than any of our other specialities, may not have escaped (Hample, 1977).

So we find ourselves in an awkward collective position. On one hand, we are inclined to insist that people do not reason logically. But we persist in

theorizing logically ourselves (e.g., Berger & Calabrese, 1975), and in attributing logic-following behavior to other organisms (see Dennett, 1981, p. 229). How can we reconcile these impulses?

We must begin by admitting that people make frequent errors on straightforward tests of logical reasoning. However, in problem solving, quite a few things can go wrong: the premises may have been misunderstood, the instructions might not have been clearly given, the subject may have been fatigued or distracted, or the reasoning may have been alogical (Henle, 1962; 1978; Ceraso & Provitera, 1971; Helsabeck, 1975; Pitz, 1975; Revlin & Leirer, 1978; Begg & Harris, 1982). Everything considered, the fact that people don't perform perfectly (or even well) in logic studies does not prove that the fundamental human information processing system is not logical. This is not quite the same as proving that reasoning is logical, of course, but at least a prima facie objection to much of our theorizing is removed.

To say that we have a choice between regarding humans as logical or alogical is to misstate the issue. A better question is whether logic or alogic is a sounder model of human thought. Put this way, the question is easily answered, because we have no comprehensive alternative model of alogic. To be sure, we have evidence for an atmosphere effect, errors due to familiarity, difficulty engendered by the presence of negatives, and tendencies to insist on substantive conclusions when none are really valid (see Wason & Johnson-Laird, 1972; and Evans, 1982, for literature reviews). But these are all errors of logic: that is, they are departures from the basic logical model. As theorists, we see human reasoning in terms of logic and exceptions to logic. We lack a complete alogical model. We will therefore no doubt continue to use logic in our work, no matter how loud the protestations, at least for the forseeable future. Given our fundamental but uneasy dependence on logic, research on syllogisms ought to be a disciplinary priority. But only a few current empiricists are devoting much attention to the main issues (Miller, 1969;

Cronen & Mihevc, 1972; Steinfatt, Miller & Bettinghaus, 1974; Hample, 1982c; Jackson, 1982). The present paper reports results from several experiments designed to explore the fit between logical models and human behavior.

## Concreteness and Negation

This study explores the effects of two variables, concreteness of premises and whether or not the problem contains a negative, on the difficulty of several kinds of reasoning tasks. Hypothetical (if p then q; p; so q), inclusive disjunctive (either p or q; not p; so q; where "or" is defined as "p or q, and maybe both"), and linear syllogisms (A is taller than B; B is taller than C; so A is taller than C) are all important sorts of problems, both in logic and in cognition.

The first independent variable is concreteness. Concreteness is closely associated with imagery (Paivio, Yuille & Madigan, 1968; Williams, 1979). Paivio (1971) presents a dual coding theory of human information processing in which he maintains that abstract, verbal materials are handled with one processing modality, and that concrete, imagic stimuli are dealt with in another way. Verbal processing is linear, order-dependent and sequential; it seems therefore to be the natural locus for logic in the human mind. Imagic processing, in contrast, is organic, perspectival and order-independent; we should therefore expect that imagic materials will be handled alogically (see Hample, 1982a). Because concrete stimuli are usually easier to remember and comprehend (Barclay, 1973; Barresi & Silbert, 1976; Evans & Newstead, 1980), the usual prediction is that concreteness facilitates processing. But Hample (1982b) has recently reported that his cognitive model of argument, which is built from two hypothetical syllogisms, does in fact work better for abstract messages. Pertinent results in a study on categorical syllogisms were somewhat equivocal: concreteness only impaired performance on positive, extremely difficult problems (Hample, 1982c). More directly relevant is a study on conditional syllogisms in which concreteness did not improve performance (Manktelow

& Evans, 1979). And Roberge (1977) reports that concreteness does not always improve accuracy with inclusive disjunctive syllogisms. These findings and the expectation they produce are not the traditional ones. Ordinarily, concrete syllogisms are reported to be easier to solve accurately, but most of the previous research on concreteness and reasoning is not on point because the abstract conditions in those studies use symbols rather than abstract words (see Wason & Johnson-Laird, 1972; Evans, 1982); this is true of the Roberge study just cited, for instance. So the present paper predicts that for hypothetical and disjunctive syllogisms, abstract problems will be more accurately solved than concrete ones. This hypothesis is grounded in the idea that concrete materials will tend to be processed in the alogical modality.

But linear syllogisms pose a special problem. They may very well be normally processed visually, not abstractly. De Soto, London and Handel (1965; see Sternberg, 1980) report that subjects picture the terms of a series problem, and then "read off" the conclusion from their mental image (try it: Aaron is lighter than Bill; Bill is lighter than Carl; who is lightest?). On this supposition, imagic processing may be a comfortable modality for linear syllogisms. Therefore the usual abstraction increment ought to disappear. Concretely worded problems might actually prove easier, but the literature only justifies the hypothesis that for linear problems, the advantage of abstract over concrete materials will be significantly reduced.

Generally, the presence of a negative in a problem makes it harder (see Wason & Johnson-Laird, 1972). Hample (1982c), however, discovered that negatives can actually improve solution rates when problems are very hard, and that this effect also appeared undetected in several previous papers (Wilkins, 1928; Ceraso & Provitera, 1971; Steinfatt, Miller & Bettinghaus, 1974). Hample speculates that negatives destroy imagic quality (e.g., what is the image for "he did not eat an apple"?), and so makes abstract processing necessary. If concrete thinking

were ever superior to abstract, presence of a negative ought therefore to eliminate the advantage by forcing abstract processing of the concrete materials. Consistent with the bulk of previous research, this paper hypothesizes that negation will generally impede accuracy. However, evidence replicating Hample's report will also be sought. Furthermore, if concrete linear syllogisms prove to be easier than abstract ones when the whole problem is positive, negation ought to reduce or reverse this superiority.

## Method

Though this paper reports three essentially separate studies--on hypothetical, inclusive disjunctive and linear syllogisms--all had the same basic design, and data were collected simultaneously from the same subject pools.

Subjects were undergraduates enrolled in either a university-required public speaking course or in a large semantics class which attracts most of its students from outside the department. In the hypothetical syllogisms study, 71 students provided full data sets, and 3 others were rejected because of excessive missing data. Of the 71, 63% were male and 37% female. Most--63%--were juniors or seniors. For the disjunctive syllogisms, 67 responded completely, and only 1 student was discarded. These respondents were more evenly divided by gender, with 51% being male and 49% female. They also tended to be upperclassmen, with 72% being juniors and seniors. In the linear study, 67 students reponded completely, and 5 were discarded. Only 48% of the linear subjects were male, and 52% were female. Of the 67, 74% were juniors or seniors. Students were assigned randomly to the studies by shuffling booklets prior to distribution.

Booklets contained either hypothetical, disjunctive or linear syllogisms. Each began with an introduction which explained the distinction between "valid" and "true," and gave an example of a valid untrue categorical syllogism. The disjunctive booklets instructed students to be aware that in the problems to follow,

"or" meant "one or the other, and maybe both;" an illustration was also provided. Students were asked to specify their gender, year in school, and whether they had ever studied logic ("never/for a few weeks/for a whole course or more").

Four forms of each kind of syllogism were used in these studies. The forms are displayed schematically in Figure 1. For each problem, students were

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INSERT FIGURE 1

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given the two premises and instructed to write out a valid conclusion. The booklet introductions all warned that "no conclusion" would often be correct. The problems used a variety of natural language connectives. Premise examples are: "if there is no opinion, then there is truth," "if he had a reminder, then he was at fault" (hypothetical); "he had either an idea or an opinion," "either his mood or his memory would have to disappear" (disjunctive); "origins are less valuable than virtue," "one's mother is more important than a policeman" (linear). Each template was used several times in its booklet. This variety in phrasing was judged to be necessary to combat subject boredom.

Half the problems were given with positive premise components, and half included a negative. For the hypothetical and disjunctive syllogisms, the p's and q's (see Figure 1) are clauses which could be positive ("he had virtue") or negative ("he had no knowledge"). Whether the p or q contains an internal negative does not affect the validity of the form. (Of course, an external negative, as in the second premise of several hypothetical and disjunctive forms, does affect validity.) Negation was therefore manipulated internally for hypothetical and disjunctive syllogisms. The manipulation was a little different for the linear problems, since their components are nouns rather than clauses. Linear problems were negated by adding "not" to the relational connective. So instead of "justice is more important than truth," we might have "justice is not more important than truth." Readers should notice that "not more important" is not logically equivalent to "less

important." Therefore, the negation manipulation halves the number of valid linear problems, although it does not affect the hypothetical or disjunctive syllogisms in this way.

Half the problems used concrete nouns and half used abstract words. All nouns were taken from the list given by Paivio, Yuille and Madigan (1968). Paivio and his colleagues report concreteness and imagery norms, which range from 1 to 7, for various nouns. Only words with Thorndike-Lorge frequencies of A or AA, or which the author felt would surely be familiar to college students, were selected. For the hypothetical problems, the concrete words had a mean rating of 6.4 on concreteness and 6.1 for imagery. The abstract condition had respective means of 1.9 and 2.6. Words chosen for the concrete condition in the disjunctive study had a concreteness mean of 6.4, and an imagery mean of 6.1. The abstract words had means of 1.9 and 2.6. In the linear problems, means for the concrete words were 6.5 and 6.2, and for the abstract words, 2.0 and 2.7. Williams (1979) reports a correlation of .91 between his ratings and those of Paivio, et al. Imagery and concreteness are almost completely confounded, and will be treated as synonyms here (Paivio, et al., 1968; cf. Richardson, 1980). Words were selected for use not only to satisfy concreteness, imagery and familiarity requirements, but also to generate sensible (i.e., arbitrary but not bizarre) syllogisms. Many words were used in all three experiments.

The basic 4x2x2 design (form x negation x concreteness) was also replicated once, so that each condition was represented twice. Thus each booklet contained 32 syllogisms. The problems were randomly ordered and typed onto 3 pages. The pages were systematically reordered so that each page took each position about a third of the time.

After finishing the problems, students proceeded to the booklet's final page, which asked whether they had a special method for solving the problems, and whether they formed mental images. Students required about 15-20 minutes to finish.

At the end of the sessions, subjects were debriefed and given the correct answers.

## Results

### Reliability

Because of the replication factor, the design allows parallel items to be correlated with one another. The average item-item correlation (using the r to z transformation) is .56 for the hypothetical problems, .45 for the disjunctive syllogisms and .59 for the linear items. These figures are low, but the fault is not with the items; the correlations are smaller than usually acceptable reliability coefficients because of the length of the "tests" (viz., 2). If the design had allowed four replications of each problem type, the coefficients would be .72, .62 and .74; with eight replications, results would be .84, .77 and .85 (this is due to the Spearman-Brown prophecy formula; see, e.g., Magnusson, 1967, ch. 5). Had the "tests" been of more normal length, reliabilities would have been much higher. However, some subjects complained of boredom with the present 32-item instruments. The author's previous experience with logic studies indicated that booklets long enough to test all the hypotheses with more replications would have seriously reduced the validity of the data.

The primary implication of the low reliabilities is that the data contain quite a lot of error. Since the usual assumption is that such error is random, this means that in the analyses to follow, less systematic variance than usual is available to be explained. Therefore, the analyses will be generating conservative results.

### Possible Covariates

In addition to the variables specified in the hypotheses, several other factors might potentially affect results. Variables of this type were gender, year in school, and experience in logic courses. Students' closing observations were

also coded according to whether or not the student claimed to have a special method for solving the problems, and whether or not the student had mental images while working. None of these deserved to be used as covariates in the hypothesis analyses. Of the six variables, only one, method, produced a significant main effect, and that was confined to the linear data. The other 17 main effects were nonsignificant. These variables produced a few significant interactions with one another and with hypothesis variables, but no more than chance would predict (see, e.g., Steinfatt, 1979). The hypotheses are therefore tested without covariates.

Data Description

A few results which do not bear directly on the hypotheses are worth noting. The mean percentage of correct answers is 54% for the hypothetical problems, 52% for disjunctive and 54% for linear. These results do not conform to Van Duyne's (1974) report that hypothetical problems are easier than disjunctive ones when realistic (i.e., nonsymbolic) materials are used. But differences in design or sample size (Van Duyne's N is 24) could easily account for this discrepancy.

Students' reponses were coded as containing a negative or not: 33% of the conclusions offered to hypothetical premises contained one, as did 41% of the disjunctive answers and 5% of the linear ones. These results are interesting in light of the atmosphere effect for categorical syllogisms, which says that negative premises tend to elicit negative answers (Wilkins, 1928; Woodworth & Sells, 1935; cf. Mandtelow & Evans, 1979). For comparison, 75% of the hypothetical and disjunctive problems had a negative in a premise, and 50% of the linear problems did. If there is an atmosphere effect, the present data suggest that it is confined to categorical syllogisms.

A last set of results of incidental interest is the proportion of students who had mental images during problem solving: 22% of the hypothetical subjects reported images, as did 24% of the disjunctive subjects and 30% of the linear ones.

This result offers support for the notion that linear problems are more naturally handled imagically, but suggests that the effect is not a dramatic one. It also indicates that concretely worded problems are not automatically coded imagically, since all the students solved 16 concrete problems. These percentages may be depressed, however, because after answering yes or no to "when solving the problems, did you form any mental images or pictures?" subjects responding yes were asked to give details; some fatigued subjects who did have images might therefore have answered no to avoid extra labor.

Hypothesis Tests

Hypothetical Syllogisms. Table 1 displays the pattern of solution accuracy for these problems. Multivariate analysis of variance reveals significant main effects

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INSERT TABLE 1

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for concreteness ($F=4.27$, $p<.05$; the concrete problems are easier) and form ($F=45.32$, $p<.001$; the valid problems are easier), but not for negation ($F<1$). Results also show a significant negation x form interaction ($F=4.89$, $p<.01$; negated problems are easier for the invalid forms, but harder for the valid ones). The significant interaction renders the interpretation of the form main effect nugatory. All other interactions are insignificant.

Disjunctive Syllogisms. Means for correct solutions are in Table 2. MANOVA reveals significant main effects for concreteness ($F=10.10$, $p<.01$; abstract problems are

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INSERT TABLE 2

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easier), negation ($F=31.44$, $p<.001$; negatives make problems harder) and form ($F=118.38$, $p<.001$; valid forms are easier), as well as one significant interaction, negation x form ($F=4.71$, $p<.01$; positive valid problems are easiest). Other interactions are insignificant.

Linear Syllogisms. Table 3 contains the means for solution accuracy. Significant main effects appear for negation ($F=87.59$, $p<.001$; negatives make problems harder)

INSERT TABLE 3

and form ($F=50.97$, $p<.001$; forms 1 and 2, which include the only valid forms, are easiest), but not for concreteness ($F<1$). No interactions are significant.

Evaluation of Hypotheses. Abstract problems were predicted to be easier for both hypothetical and disjunctive tasks. This effect occurs only with hypothetical syllogisms; the opposite result appears with disjunctive ones. As predicted, the abstractness advantage disappears with linear problems.

Negation was theorized to interfere with imagic processing, and so to force abstract thinking. If accurate, this prediction would have been reflected in significant negation x concreteness interactions. The concreteness advantage for disjunctive syllogisms seems unaffected by negation (see Table 2), and no negation x concreteness interaction appears. With hypothetical syllogisms, most of the abstraction increment is supplied by the positive problems (see Table 1), suggesting that concrete negatives are handled in the same way as abstract negatives; however, the negation x concreteness interaction is insignificant here, too. The linear results (Table 3), while they do not yield a significant effect for concreteness, show a nonsignificant tendency for concrete problems to be easier than abstract ones when problems are wholly positive, but this tendency disappears for negated syllogisms. But the critical negation x concreteness interaction is insignificant. In sum, the data do not support the claim that negatives help determine the cognitive system in which problems are solved.

Negation was also predicted to make problems generally harder. This result appears clearly for disjunctive and linear syllogisms. With hypothetical problems, negation interacts with form. The predicted effect occurs for valid

forms, but the opposite was found with invalid syllogisms. As Table 1 shows, the invalid problems are harder. This interaction is therefore parallel to Hample's (1982c) report that with categorical syllogisms, negatives make very difficult problems easier, but increase errors on all others.

## Discussion

Though it is wise to be on guard against the insistence that things true of one kind of reasoning should necessarily be true of the others, some common results have nonetheless appeared.

In all three kinds of tasks, problems with valid substantive conclusions are easiest. This effect has been noticed in a variety of reasoning tasks (Taplin, 1971; Taplin & Staudemayer, 1973; Jansson, 1977; Roberge, 1977; Hample, 1982c). In the present studies, the effect might be thought to be due to subjects' preference for writing out substantive conclusions rather than the weaker-appearing "no conclusion." But the validity increment also appears with multiple-choice formats (e.g., Hample, 1982c) and when subjects need merely say if a stated conclusion is correct or not (e.g., Roberge, 1977; Jansson, 1977). On the assumption that one's environment will more often punish invalid than valid reasoning, we are justified in supposing that valid forms are more familiar to most people. That subjects perform better on valid problems is therefore not surprising.

Another possible explanation, however, is that people prefer not to offer negative or null conclusions of any kind--whether in the form of a negative conclusion, a statement that an offered conclusion is wrong, or a "no conclusion" decision. This study's finding that negatively-stated conclusions are rare offers some support for this explanation, as do the reports of acquiescence response sets in unrelated research (see, e.g., Jackson, 1967; Messick, 1967). If subjects give substantive answers for the most part, they only have a chance of getting the valid forms right very often.

Both explanations are plausible, but have different implications for the quality of students' reasoning. The latter explation could be simply tested by measuring acquiescence response set along with problem solving behavior, and using the response set measure to predict frequency of negative and null answers.

Negation results also show some consistency. Only for linear problems is a simple interpretable main effect for negation present; there, as one would expect, negation impedes accuracy. Both the hypothetical and disjunctive tasks, however, produced a significant interaction between negation and form. For the disjunctive syllogisms, the interaction means that the positive valid problems are the easiest, and the negated invalid ones hardest. This is no more than an exaggeration (due to validity) of the main effect: a cell by cell comparison of Table 2 shows that the negated version of each problem is always harder than the corresponding positive one. These results are consistent with those of Evans and Newstead (1980), who use only valid disjunctive problems.

The interaction in the hypothetical data is considerably more interesting. The usual negation effect--of making problems harder--appears, but only for the valid problems. For invalid forms (the harder ones), the negated versions are actually easier than the positive ones. This outcome replicates Hample's (1982c) report that for very difficult categorical syllogisms, negation improves solution accuracy; this was also true in three studies whose data Hample reanalyzed (Wilkins, 1928; Ceraso & Provitera, 1971; Steinfatt, Miller & Bettinghaus, 1974). Hample's explanation of this phenomenon was that negation impedes imagic processing and so stimulates use of the abstract, more logic-oriented modality. That theory has been tested here, and the failure to find significant negation x concreteness interactions counts strongly against it.

Due to the present results, we have a few more clues to the puzzle of why negation should sometimes improve reasoning outcomes. First, we know now that the effect is not restricted to categorical syllogisms, but that it does not

extend to linear or disjunctive ones. The underlying logical structure is therefore unlikely to be the key: Evans (1982, ch. 10) points out that disjunctives can be converted into hypotheticals, and three-term linear series problems are similar to ordinary categorical syllogisms. But we have found the effect for hypothetical (but not disjunctive) and categorical (but not linear) tasks. Second, invalidity may be necessary for the effect to occur. In Hample (1982c), the problems which show the effect are both invalid; here, too, it appears only for the invalid forms. Since the invalid problems in both studies are the hardest, the data cannot distinguish difficulty from invalidity. This unclarity can be resolved only if very difficult valid and invalid problems can be found. The Wason task, which is usually the experimental paradigm in hypothetical and disjunctive studies, lacks invalid formulations, and the hardest problems used by Hample are all invalid. This explains, incidentally, why this effect has not been reported by workers using the popular Wason paradigm.

A possible explanation for the effect in hypotheticals is that negatives cue a "no conclusion" answer, which of course is correct for invalid problems. If this were the case, it should also happen for the "external" negatives (i.e., forms 2 and 4 in Table 1; see Figure 1), lowering the number of correct answers to form 2 (which has a correct substantive conclusion) and increasing accuracy on form 4. As Table 1 shows, this does in fact occur: form 2 is always harder than form 1, and form 4 is easier than form 3. So the accuracy increment might not be due to improved reasoning, but to a greater temptation to give up on the effort of finding a satisfactory substantive conclusion. The main difficulty with this explanation is that it does not account for the effect being limited to hypothetical and categorical tasks. For both the disjunctive and the linear problems, if negatives cue "no conclusion" answers, subjects ought to have shown more accuracy for negated problems than for wholly positive ones, but this is very clearly not the case (see Tables 2 and 3). That this kind of cuing should be specialized to hypothetical

and categorical tasks does not seem immediately credible, so we must count the effect as still being unexplained. More research may help to clarify its nature, and so yield more clues.

The concreteness results are nearly those which were hypothesized. Abstractly worded problems are in fact easier in disjunctive reasoning, and this effect disappears with linear problems, as was expected. The superiority of concrete wording in hypothetical syllogisms, however, is exactly opposite of what was predicted.

This poses two difficulties: If concrete problems are easier anywhere, why not for linear tasks? and Why isn't abstract wording easier for hypotheticals? The first question is plausibly answered by the observation that the linear subjects were only a little more likely to report using images. This small increment may only have been enough to blunt the normal advantage of abstract wording, but not enough to reverse it. This supposition can be simply tested by giving instructions to use images, which ought to exaggerate the imagery effect.

But this leaves the second question. The present finding of an advantage for concrete wording in hypothetical problems is inconsistent with earlier work, but task differences may well explain this. Hample (1982b) found adherence to the claims of abstract messages to be better modeled with an equation built from two hypothetical syllogisms, but his subjects were not solving problems: they only indicated their beliefs about the message topic. Roberge (1977) and Manketlow and Evans (1979) report no increment for concreteness, but their comparison is to symbolic materials, not to abstract wording. Besides, the Wason task, which Manketlow and Evans use, involves physical stimuli--cards with items written on front and back--which may well mean that all their conditions ought to be regarded as concrete. The preference of the present hypothetical subjects for concrete wording is unlikely to be related to imagery, since hypothetical and disjunctive

subjects report about the same frequency of imagery use. The effect may therefore be due to the fact that hypothetical and disjunctive problems involve different kinds of reasoning, in spite of their common logical structure: "where two linguistic forms exist to denote the same logical relationship, they probably relate to different contexts in natural language usage" (Evans, 1982, p. 189). As noted earlier, concreteness is widely reported to facilitate memory and comprehension. Perhaps the different natures of hypothetical and disjunctive reasoning allow the comprehension advantage of concreteness to facilitate one kind of thinking, and abstraction's affinity for logical processing to improve the other. The differences in the two kinds of reasoning will have to be spelled out to make this explanation very satisfying, but the present data are unhelpful in that regard.

## Conclusions

In sum, this paper provides evidence that valid problems are easier to solve than invalid ones; that negation makes syllogisms harder, except for invalid/difficult hypothetical and categorical problems; and that the effect of concreteness is dependent on the type of reasoning task.

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Table 1

Mean Correct Answers for Hypothetical Syllogisms

| Negation: | | Internal Negative Premise | | Internal Positive Premises | |
|---|---|---|---|---|---|
| Wording: | | Abstract | Concrete | Abstract | Concrete |
| Form: | 1 | 1.82 | 1.93 | 1.94 | 2.00 |
| | 2 | 1.10 | 1.03 | 1.00 | 1.17 |
| | 3 | .48 | .58 | .42 | .52 |
| | 4 | .90 | .90 | .83 | .82 |

Note. Since there are two problems per cell, the maximum is 2. For specification of the syllogisms' forms, see Figure 1. Forms 1 and 2 have valid substantive solutions. Forms 2 and 4 have an external negative in their premises.

Table 2

Mean Correct Answers for Disjunctive Syllogisms

| Negation: | | Internal Negative Premise | | Internal Positive Premises | |
|---|---|---|---|---|---|
| Wording: | | Abstract | Concrete | Abstract | Concrete |
| Form: | 1 | 1.27 | 1.19 | 1.69 | 1.64 |
| | 2 | 1.70 | 1.52 | 1.87 | 1.82 |
| | 3 | .48 | .42 | .61 | .52 |
| | 4 | .43 | .46 | .61 | .49 |

Note. Since there are two problems per cell, the maximum is 2. For specification of the syllogisms' forms, see Figure 1. Forms 1 and 2 have valid substantive solutions.

Table 3

Mean Correct Answers for Linear Syllogisms

| Negation: | | Negative Premise | | Positive Premises | |
|---|---|---|---|---|---|
| Wording: | | Abstract | Concrete | Abstract | Concrete |
| Form: | 1 | 1.08 | 1.05 | 1.61 | 1.80 |
| | 2 | .94 | .97 | 1.59 | 1.62 |
| | 3 | .65 | .45 | 1.08 | 1.08 |
| | 4 | .58 | .64 | 1.09 | 1.00 |

Note. Since there are two problems per cell, the maximum is 2. For specification of the syllogisms' forms, see Figure 1. Forms 1 and 2 have valid substantive solutions, but only for problems will all positive premises.

Figure 1

Syllogism Forms

| | | | |
|---|---|---|---|
| **Hypothetical** | | | |
| (1) If p, then q | (2) If p, then q | (3) If p, then q | (4) If p, then q |
| p | not q | q | not p |
| q | not p | no conclusion | no conclusion |
| **Disjunctive** | | | |
| (1) p or q | (2) p or q | (3) p or q | (4) p or q |
| not p | not q | p | q |
| q | p | no conclusion | no conclusion |
| **Linear** | | | |
| (1) A > B | (2) A < B | (3) A > B | (4) A < B |
| B > C | B < C | B < C | B > C |
| A > C | A < C | no conclusion | no conclusion |

Note. The numbers in parentheses are the form numbers referred to throughout the text and tables.